REMARKS

Claims 1-3, 8, 9, 11 and 15-23 are pending in this application. By this Amendment, a typographical error in the specification is corrected, claims 1 and 15 are each amended to recite that the pressure in the system at the start of the supply of the carboniferous liquid state material is 1.3 Pa (0.01 torr) or less (as supported in the original specification at least at page 10, first and third full paragraphs), and claims 20-23 are added (claims 20 and 22 being supported in the original specification at least at the bottom of page 9, and claims 21 and 23 being supported in the original specification at least at page 12, third full paragraph).

The courtesies extended to Applicant's representative by Examiner Lish at the interview held April 22, 2004, are appreciated. The reasons presented at the interview as warranting favorable action are incorporated into the remarks below and constitute Applicants' record of the interview.

I. Rejections Under 35 U.S.C. §103(a)

A. Withers in View of Chiharu

Claims 1-3, 8, 11 and 15-17 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over U.S. Patent No. 5,876,684 (Withers) in view of JP 11-116218 (Chiharu). This rejection is respectfully traversed.

By way of background, the presently claimed invention relates to a method of manufacturing single-walled carbon nanotubes (claim 1) or any carbon nanotube (claim 15) by reducing the pressure inside a system to 1.3 Pa (0.01 torr) or lower, and when the pressure inside the system is 1.3 Pa or lower, initiating supply of a carboniferous liquid state material comprising a metallic catalyst, the pressure inside the system being raised to at least 39.9 kPa, generating arc discharges, supplying the carboniferous liquid state material in discharge plasma created by the arc discharges, and disintegrating or exciting the carboniferous liquid state material to produce the recited carbon nanotubes. These methods are able to efficiently

and effectively produce a large number of the recited carbon nanotubes. Applicants respectfully submit that neither Withers nor Chiharu teach or suggest these recited methods.

Withers describes various procedures for producing fullerenes by subjecting carbon either in the form of particulates or as the carbon of a liquid or gaseous hydrocarbon to intense heat-generating processes that can include arc discharge processes. See the Abstract. Methods in which hydrocarbon gases, liquids or solids are used in place of carbon particles are described at cols. 9-12 of Withers. In particular, at cols. 9-12, distinctions between the use of hydrocarbon gases, liquids or solids and the use of carbon particles are detailed.

At col. 10, lines 40-48, it is described that in a case where hydrocarbon is introduced into an arc system, the pressure is preferably set to between 100 and 200 torr, but may cover the range of about 10^{-6} torr up to several atmospheres. The Patent Office cites this passage of Withers as allegedly suggesting the pressure inside the system of the present methods of at least 39.9 kPa. The Patent Office further cites to Example 1 of Withers, teaching evacuating the system to a pressure of 10^{-3} torr before pressurizing the system and creating the arc, as allegedly suggesting initially reducing the pressure inside the system to 1.3 Pa (10^{-2} torr) or lower as required in the presently claimed methods.

Applicants respectfully submit that these teachings of Withers would not have led one of ordinary skill in the art to the presently claimed invention. Specifically, the methods of claims 1 and 15 require that the pressure inside the system be reduced to 1.3 Pa or lower, and that when the pressure inside the system is 1.3 Pa or lower, the supply of the carboniferous liquid state material is initiated, at which time the pressure inside the system is raised to at least 39.9 kPa. These required process steps are nowhere taught or suggested in Withers.

First, Applicants respectfully submit that Example 1 in col. 13 of Withers is not applicable to the presently claimed invention. Example 1 in Withers relates to a method of producing fullerenes in which carbon particles are introduced into the system shown in Fig. 1

of Withers. Such example thus does not relate to the use of hydrocarbon liquids or gases in the production of fullerenes. Withers itself extensively teaches the distinctions between the use of carbon particles in making fullerenes as in Example 1, and the use of hydrocarbon liquids and gases in making fullerenes. See cols. 9-12 of Withers. In view of the distinctions between the use of these different starting materials, one of ordinary skill in the art would have found nothing in Example 1 of Withers to indicate that such conditions for use with carbon particles should or could have also been followed in making fullerenes with the use of a hydrocarbon liquid or gas starting material.

Second, even if one of ordinary skill in the art were to have looked to Example 1 for conditions in operating a system when using a hydrocarbon liquid or gas as the starting material, the conditions in Example 1 of Withers still would not have led such practitioner to the presently claimed invention. Specifically, although Example 1 indicates that the system is initially pumped to 10^{-3} torr, it further teaches that the system is backfilled to 200 torr with helium prior to start of the process. To the contrary, the methods of claims 1 and 15 require that the pressure inside the system be 1.3 Pa (0.01 torr) or lower at the time of initiation of the supply of carboniferous liquid state material. Nothing in Example 1 of Withers teaches or suggests such a starting pressure. Moreover, nothing in Example 1 of Withers teaches or suggests that following the initiation of the procedure, the pressure inside the system must change from an initial point of 1.3 Pa or lower to 39.9 kPa or more.

These operating pressure distinctions, nowhere taught or suggested in Withers, are not insignificant with respect to the presently claimed methods. As was discussed extensively in the Amendment filed November 4, 2003, preparing carbon nanotubes following the methods of the presently claimed invention produces a dramatically increased nanotube yield that one of ordinary skill in the art would not have expected from the teachings of Withers. In particular, the previously submitted Shimotani et al. article examined nanotube synthesis

under various atmospheres at different pressures, using methods falling within the scope of the instant claims. As shown in Fig. 4 of Shimotani et al., nanotube yield dramatically increases as the pressure increases from 200-300 torr. As the pressure was further increased, nanotube yield continued to increase until leveling off at a pressure of about 400-500 torr. High yields of carbon nanotubes were achieved. Such evidence further supports the novelty of the presently claimed methods over the teachings of the prior art.

Chiharu was cited as allegedly suggesting the inclusion of a metallic catalyst in the hydrocarbon feed of Withers. However, as Chiharu also fails to teach or suggest methods of making carbon nanotubes in which supply of a carboniferous liquid state material is initiated only when the pressure inside the system is 1.3 Pa or lower and the pressure inside the system is then raised to at least 39.9 kPa, Chiharu remedies none of the extensive deficiencies of Withers discussed above.

For at least the foregoing reasons, Applicants respectfully submit that Withers and Chiharu, whether taken singly or in combination, would not have led one of ordinary skill in the art to the presently claimed methods. Reconsideration and withdrawal of this rejection are respectfully requested.

B. Withers in View of Chiharu, and Further in View of Ebbesen

Claims 1-3, 8, 11 and 15-17 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Withers in view of Chiharu, and further in view of Ebbesen ("carbon nanotubes preparation and properties"). This rejection is respectfully traversed.

In this rejection, Ebbesen was further relied upon as allegedly teaching that in arc discharge formation of carbon nanotubes, good yields may be obtained at pressures between 500 and 600 torr. Ebbesen was thus relied upon as allegedly further suggesting operation of an arc discharge system at a pressure of at least 39.9 kPa.

Applicants respectfully submit that even if the teachings of Ebbesen as summarized in the Office Action are accepted, Ebbesen still would not have led one of ordinary skill in the art to the presently claimed invention. That is, like Chiharu, nothing in Ebbesen teaches or suggests initiating supply of a carboniferous liquid state material into the system only when the pressure inside the system is 1.3 Pa or lower, and then raising the pressure inside the system to at least 39.9 kPa.

Accordingly, Applicants respectfully submit that even if the teachings of Withers, Chiharu and Ebbesen are taken together, the presently claimed invention still would not have been achieved. Reconsideration and withdrawal of this rejection are respectfully requested.

C. Withers in View of Chiharu, and Further in View of Journet

Claim 9 was rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Withers in view of Chiharu, and further in view of Journet ("large-scale production of single-walled carbon nanotubes by the electric-arc technique"). This rejection is respectfully traversed.

Journet was relied upon by the Patent Office as allegedly teaching the use of a mixture of yttrium and nickel particles as a catalyst in the production of single-walled carbon nanotubes formed in an electric-arc process.

However, Journet also fails to teach or suggest a process of making carbon nanotubes in which the supply of a carboniferous liquid state material is initiated in a system when the pressure inside the system is 1.3 Pa or lower, and the pressure inside the system is thereafter raised to at least 39.9 kPa as recited in the present claims. Accordingly, Applicants respectfully submit that even if the teachings of Journet were to have been considered together with the teachings of Withers and Chiharu, one of ordinary skill in the art still would not have been led to the presently claimed invention. Reconsideration and withdrawal of this rejection are respectfully requested.

D. Withers in View of Chiharu, and Further in View of Bethune

Claim 19 was rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Withers in view of Chiharu, and further in view of Bethune (U.S. Patent No. 5,424,054). This rejection is respectfully traversed.

Bethune was relied upon as allegedly teaching a process for the formation of carbon nanotubes using electric arc in which the arc is established by bringing the anode and the cathode into contact and then separating them by a short distance.

However, Bethune fails to remedy any of the extensive deficiencies of Withers discussed above. In particular, nothing in Bethune teaches or suggests a method of manufacturing carbon nanotubes in which initiation of a supply of a carboniferous liquid state material is begun when the pressure inside the system is 1.3 Pa or lower and the pressure inside the system is thereafter raised to at least 39.9 kPa. Thus, Applicants respectfully submit that Withers, Chiharu and Bethune, whether taken singly or in any combination, would not have led one of ordinary skill in the art to the presently claimed methods.

For at least the foregoing reasons, reconsideration and withdrawal of this rejection are respectfully requested.

E. Withers in View of Chiharu, Further in View of Ebbesen, and Still Further in View of Bethune

Claim 19 was rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Withers in view of Chiharu, further in view of Ebbesen, and still further in view of Bethune. This rejection is respectfully traversed.

As extensively discussed above, none of Withers, Chiharu, Ebbesen or Bethune teach or suggest a process of making carbon nanotubes in which the pressure inside the system is first reduced to 1.3 Pa or lower, the supply of a carboniferous liquid state material is initiated when the pressure inside the system is 1.3 Pa or lower, and the pressure inside the system is then raised to at least 39.9 kPa.

Accordingly, Applicants respectfully submit that none of these references, whether taken singly or in any combination, would have led one of ordinary skill in the art to the presently claimed invention. Reconsideration and withdrawal of the rejection are thus respectfully requested.

F. Zettl

Claims 1, 2, 8, 9, 11, 15, 16 and 18 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Zettl (U.S. Patent No. 6,063,243). This rejection is respectfully traversed.

Zettl describes a method for making nanotubes and nanoparticles using an apparatus in which at least one of the anode and the cathode have an interior conduit for delivery and withdrawal of material from the arc region where the product is formed. See the Abstract. As further described at col. 2, lines 18-22, the conduits may be used for many purposes, including injecting gaseous, liquid or particulate material from the electrode into the arc region. At col. 3, lines 27-31, it is described that the chamber pressure is set to be between about 100 and about 1,000 torr, more typically around 650 torr. Applicants respectfully submit that Zettl clearly fails to teach or suggest the presently claimed invention.

First, nowhere does Zettl teach or suggest a method of manufacturing carbon nanotubes in which the method comprises the steps of reducing the pressure inside a system to 1.3 Pa or lower, initiating supply of a carboniferous liquid state material into the system when the pressure inside the system is 1.3 Pa or lower, and then raising the pressure inside the system to at least 39.9 kPa.

In the Office Action, it is acknowledged that Zettl does not teach or suggest having a chamber reduced to a pressure of 1.3 Pa or lower prior to initiation of the supply of carboniferous liquid state material. However, the Patent Office concludes, with no citation to any prior art reference whatsoever, that it allegedly would have been obvious to one of

ordinary skill in the art to bring the chamber under vacuum conditions such as below 1.3 Pa in order to ensure that the inert gaseous atmosphere in which the reaction takes place is uncontaminated.

Applicants respectfully submit that this rejection is improper and must be withdrawn. In particular, nowhere does Zettl teach or suggest a method of making carbon nanotubes in which the pressure must be reduced to 1.3 Pa (0.01 torr) or lower at the time of initiation of the supply of carboniferous liquid state material into the system. The Patent Office merely makes a conclusion of obviousness without any teachings in Zettl to support such conclusion. Such conclusion is clearly based solely upon improper hindsight, and must be withdrawn as lacking basis in the teachings of the cited prior art.

Moreover, Zettl teaches operation of the pressure in the system in the range of about 100 to about 1,000 torr (col. 3, lines 26-31). Such pressure range is nowhere near the required initial pressure of 1.3 Pa (0.01 torr) or lower in the presently claimed methods. In view of this very large pressure difference from the teachings of Zettl, clearly one of ordinary skill in the art would not have been led to the presently claimed methods from the teachings of Zettl.

For at least the foregoing reasons, Applicants respectfully submit that nothing in Zettl would have rendered obvious the presently claimed methods. Reconsideration and withdrawal of this rejection are respectfully requested.

G. Zettl in View of Chiharu

Claims 3 and 17 were rejected under 35 U.S.C. §103(a) as allegedly being unpatentable over Zettl in view of Chiharu. This rejection is respectfully traversed.

Chiharu was relied upon as allegedly suggesting the inclusion of the reactive materials of Chiharu in the process of Zettl in producing carbon nanotubes. However, as was discussed

extensively above, Chiharu fails to teach or suggest the pressure requirements of the presently claimed methods. Accordingly, Chiharu fails to remedy the extensive deficiencies of Zettl.

Accordingly, Applicants respectfully submit that even if the teachings of Zettl and Chiharu are considered together, one of ordinary skill in the art still would not have been led to the presently claimed invention. Reconsideration and withdrawal of this rejection are respectfully requested.

II. Conclusion

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance of claims 1-3, 8, 9, 11 and 15-23 are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

Respectfully submitted,

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